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(54) **Thermal treatment apparatus**

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Description

FIELD AND BACKGROUND OF THE INVENTION

[0001] The present invention relates to thermal treatment apparatus for thermally treating selected tissues of a subject. The invention is particularly useful in thermal treatment apparatus for treating prostate, bladder and uterus, and is described below particularly with respect to apparatus for treating the prostate. The invention also relates to a catheter construction, a heater, a peristaltic pump, and a thermal sensor assembly, all especially useful in the novel thermal treatment apparatus.

[0002] Thermal treatment is now a recognized form of treatment of certain types of ailments including benign prostatic hyperplasia (BPH), prostatitis, and prostate cancer. My prior US Application US-A-5 257 977, corresponding to EP-A-449 472, discloses one form of thermal treatment apparatus including a catheter insertable into the subject's urethra. The proximal end of the catheter includes an inflatable anchoring section in the form of a balloon to be anchored in the subject's bladder, and a heating section which, when the balloon is so anchored, extends through the subject's prostate. A heated liquid, such as water, is used to inflate the balloon and is also circulated through the heating section to heat the adjacent tissues of the prostate and the bladder neck.

[0003] The present invention relates to this type of thermal treatment apparatus but provides a number of important advantages, as will be described more particularly below.

BRIEF SUMMARY OF THE INVENTION

[0004] According to the present invention, there is provided thermal treatment apparatus for thermally treating selected tissues of a subject located in or near a body cavity according to claim 1.

[0005] By thus inflating the anchoring section at the proximal end of the catheter with a separate, non-heated fluid, the heating fluid may be more particularly targeted, by the inflatable heating section, to the tissue to be subjected to the thermal treatment, thereby enabling higher temperatures to be applied if desired.

[0006] Further, prefered embodiments are defined in the dependent claims.

[0007] More particularly, each of the two thermal sensor assemblies includes: a thermal sensor; a metal tube connectible to the respective end of the respective passageway of the catheter to receive the heated fluid flowing therethrough; a metal thermal coupling member formed with a recess on one face for receiving the thermal sensor therein, a recess on the opposite face complementary to the shape of the metal tube for receiving the metal tube therein, and a relatively thin web between the two recesses; and a cover pressing the metal tube to the metal thermal coupling member.

[0008] The liquid heater is particularly useful in such thermal treatment apparatus and includes a heating block formed with a semi-spherical cavity; a container defining a liquid reservoir and also formed with a semi-spherical wall removably receivable in the cavity of the heating block; a cover attached to the container; a liquid inlet tube passing through the cover for inletting a liquid into the container to be heated by the heating block; and a liquid outlet tube passing through the cover for outletting a liquid from the container after having been heated by the heating block.

[0009] According to a dependent claim, there is provided a peristaltic pump particularly useful in thermal treatment apparatus, which peristaltic pump includes a housing formed with a cylindrical cavity; and a rotor rotatably mounted within the cavity and carrying rollers engageable with a peristaltic tube insertable into the cavity for pressing the peristaltic tube against a wall of the housing in order to pump a liquid through the peristaltic tube during the rotation of the rotor; the wall of the housing including a skirt depending from a lid removably received over the cylindrical cavity; the depending skirt extending less than the circumference of the lid to produce an interruption in the housing wall against which the peristaltic tube is pressed by the rollers of the rotor.

[0010] Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Fig. 1 is a block diagram illustrating the main components of a thermal treatment apparatus constructed in accordance with the present invention;

Fig. 2 is a view, partially in longitudinal section diagrammatically illustrating one form of catheter constructed in accordance with the present invention for use in the thermal treatment apparatus of Fig. 1;

Fig. 3 is a view, partially in longitudinal section and rotated 90° with respect to Fig. 2, illustrating the catheter of Fig. 2;

Figs. 4, 5 and 6 are transverse sectional views along lines IV--IV, V--V and VI--VI in Fig. 3;

Fig. 7 is a bottom view illustrating one form of liquid heater constructed in accordance with the invention for use in the thermal treatment apparatus of Fig. 1;

Fig. 7a is a sectional view along line VIIa--VIIa of Fig. 7;

Fig. 8 is a longitudinal sectional view along line VIII-VIII of Fig. 9, and Fig. 9 is a transverse sectional view along line IX--IX of Fig. 8, of one form of peristaltic pump constructed in accordance with the invention, Fig. 9a being a fragmentary detail view along line IXa--IXa of Fig. 9;

Fig. 10 is a transverse sectional view along line X--

X of Fig. 11, and Fig. 11 is a longitudinal sectional view along line XI--XI of Fig. 10, illustrating one form of thermal sensor assembly constructed in accordance with the invention for use in the thermal treatment apparatus of Fig. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Overall Apparatus

[0012] The thermal treatment apparatus diagrammatically illustrated in Fig. 1 includes a catheter 2 insertable into a subject's body cavity to be treated thermally. In the example to be described below, the heat is applied to treat the prostate. The catheter 2 would therefore be inserted into the subject's urethra, such that one end of the catheter is anchored in the subject's bladder. This locates a heating section of the catheter in the subject's prostate.

[0013] The thermal treatment apparatus illustrated in Fig. 1 further includes a heater 4 for heating a fluid, in this case a liquid such as water, to be circulated in a closed circuit through the heating section of the catheter by means of a pump 6. The temperature of the heating liquid inletted from pump 6 into the catheter 2 is measured by a thermal sensor assembly 8, and the temperature of the liquid exiting from the catheter 2 to the heater 4 is measured by another thermal sensor assembly 10. The illustrated apparatus further includes a controller 12 which controls both the heater 4 and the pump 6 in response to the temperature sensed by sensor assemblies 8 and 10 and another sensor (to be described below) in the heater 4.

[0014] The construction of the catheter 2 is shown in Figs. 2-6; the construction of the liquid heater 4 is shown in Figs. 7 and 7a; the construction of the pump 6 is shown in Figs. 8, 9 and 9a; and the construction of the two thermal sensor assemblies 8 and 10 is shown in Figs. 10 and 11.

[0015] The catheter 2, as shown in Figs. 2-6, includes a long slender tube 20 formed with an inflatable anchoring section 21 at the proximal end for anchoring the catheter in the subject's bladder, and thereby for locating an inflatable cylindrical heating section 22 extending through the subject's prostate when the catheter is so anchored. The opposite end of the catheter, called the distal end, is to be located externally of the subject's urethra so as to be readily accessible for inflating the proximal anchoring section 21 and for inflating and circulating a heating liquid through the inflatable heating section 22.

[0016] The heating liquid is circulated through the inflatable heating section 22 via two passageways 24a, 24b having an inlet 25 and an outlet 26 at the distal end 23 of the catheter. The inflatable anchoring section 21 of the catheter is inflated by an unheated fluid, such as air, introduced via an inlet 27 at the distal end 23 and communicating with the anchoring section 21 via the third passageway 28 and an opening 29.

[0017] The portion of the catheter from the distal end 23 to the inflatable heating section 22 is thermally insulated from the subject's tissue by means of outer chambers 30 enclosing passageways 24a, 24b through which the heating liquid is circulated to the heating section 22. One of these chambers communicates with passageway 28 through which unheated air is applied to inflate the anchoring section 21.

[0018] The catheter also includes an extension 31 at the proximal end, which extension is received within the subject's bladder. Extension 31 is formed with an opening 32 for draining the subject's bladder via a passageway 33 passing through the length of the catheter and terminating in an outlet 34 at the distal end 23 of the catheter for connection to a drain. Extension 31 and its passageway 33 may also be used for introducing a drug into the bladder if desired.

The Heater 4 (Fig. 7)

[0019] The liquid heater 4, as more particularly illustrated in Fig. 7, includes a heating block 40 made of a good heat-conducting material, such as aluminum. Heating block 40 is of dome shape to define a smoothly curved semi-spherical cavity 41, and is integrally formed with four perpendicular ribs 42. A plurality of electrical heating elements 43, and one or more thermal sensors 44, are encased within the heating block 40. As seen in Fig. 7, an electrical heating element 43 is encased in each of the four ribs 42, and thermal sensor 44 is encased in each of the two opposite sides of the heating block, midway between two heating elements 43. The dome-shaped section of the heating block is relatively thin, as shown at 45 in Fig. 7a, to thereby reduce its thermal mass.

[0020] The heating block 40 illustrated in Fig. 7a further includes a removable container 50 serving as a water reservoir and formed with a complementary-curved wall 51, i.e., of semi-spherical configuration corresponding to the semi-spherical configuration of cavity 41. The semi-spherical wall 51 of container 50, however, is of slightly smaller dimensions than the heating block cavity 41 so as to provide a small gap 52 adapted to receive a small quantity of a liquid 53 to provide a good thermal coupling between block 40 and container wall 51. The semi-spherical shape of the container wall 51 permits it to be of a thin- wall construction and therefore sufficiently inexpensive so as to be disposable after one-time use. The thinness of the plastic wall also provides good thermal conductivity between heating block 40 and the interior of container 50.

[0021] Container 50 further includes a cover 54, preferably bonded by an adhesive or solvent or welded to the curved wall 51 of the container. Cover 54 is formed with a reentry tube 55 substantially centrally of the cover for receiving an inlet tube 56 which inlets into the container the liquid to be heated by the heating block 40. A

second reentry tube 57 is formed in cover 54 laterally of reentry tube 55, for receiving the outlet tube 58 which outlets the liquid from the container. The inlet reentry tube 55 extends from cover 54 substantially to the bottom of the container 50, whereas the outlet reentry tube 57 terminates close to the top of the container 50. This arrangement provides a relatively large residence time and contact surface for heating the liquid as it is circulated within container 50 from the inlet 56 to the outlet 58.

The Peristaltic Pump 6 (Figs. 8, 9 and 9a)

[0022] Pump 6 in Fig. 1 is a peristaltic pump as more particularly illustrated in Figs. 8, 9 and 9a. It includes a housing 60 formed with a cylindrical cavity 61. Disposed within cylindrical cavity 61 is a rotor 62 connected by a drive shaft 63 to a gear motor (not shown) and including a pair of spaced discs 64a, 64b rotatably mounting between them a plurality (3) of rollers 65 within cavity 61. Also located within the cylindrical cavity 61 is a peristaltic tube 66 which is engageable by the roller 65 for pumping the liquid through the tube during the rotation of rotor 62. Assuming rotor 62 is rotated counter-clockwise in Fig. 9, the liquid will be pumped through the peristaltic tube 66 from an inlet nipple 67 to an outlet nipple 68.

[0023] As shown in Fig. 8, housing 60 further includes a lid 70 formed with a large central opening 71 for accommodating disc 64 of the rotor 62. Lid 70 is formed with a depending skirt 72 which extends into the cylindrical cavity 61 such that the peristaltic tube 66 is located between the inner surface of skirt 72 and the rollers 65. Skirt 72 extends only for a part of the circumference of the lid, e.g., from 160° to 200°, to accommodate the inlet and outlet ends of the peristaltic tube 66. As shown in Fig. 9, skirt 72 extends slightly more than 180°; also, its leading edge 73 and its trailing edge 74 are tapered to provide a gradual application of the pressure to the peristaltic tube by the roller 65, and a gradual release of the pressure.

[0024] Housing 60 is of polygonal, preferably square, cross-section to provide a flat surface 60a. Lid 70 is provided with a depending pin 75 in contact with the outer flat surface 60a of housing 60 (see Figs. 9 and 9a) to prevent rotation of the lid during the rotation of the rotor 62.

[0025] The illustrated construction, including the depending skirt 72, facilitates the assembly of the peristaltic pump with the peristaltic tube 66 between the skirt and the rollers 65. Thus, with the lid removed the peristaltic tube 66 may be conveniently applied around the rollers 65. The lid 70 may then be applied with its skirt 72 received between the peristaltic tube 66 and the inner surface of the cylindrical cavity 61 formed in housing 60, so as to squeeze the tube between it and the rollers 65. For this purpose, the lower edge of skirt 72 is tapered, as shown at 76 in Figs. 8 and 9a, to facilitate the application of the skirt.

[0026] The foregoing construction not only facilitates the assembly of the peristaltic pump, but also covers the rollers 65 to minimize exposure to a person's fingers or the like. In addition, the thickness of skirt 72 influences the outlet pressure produced by the pump, so that lids 70 with different thickness skirts 72 may be provided to provide different outlet pressures. In addition, the inner surface of the skirt 72 may be provided with one or more grooves, as shown at 77 in Fig. 9, to produce a pulsatile output.

The Thermal Sensors Assemblies 8, 10

[0027] The thermal sensor asemblies 8, 10 are more particularly illustrated in Figs. 10 and 11. They are both enclosed within a common housing 80 in the shape of an "H" and closed by a common cover 81. Thermal sensor assembly 8 near the inlet end of the catheter 2 includes a thermal sensor element 82 received within a rectangular recess formed in a metal thermal coupling member 83. The opposite face of the coupling member is formed with a recess for receiving a metal tube 84 connectible to an inlet tube 85 near the inlet end of the catheter. Thermal sensor assembly 10 similarly includes a thermal sensor element 86 received within a recess formed in another thermal coupling member 87. The opposite face of member 87 is similarly formed with a recess for receiving a metal tube 88 adapted to be coupled to an outlet tube 89 near the outlet end of the catheter. Electrical connections are made to the two thermal sensor elements 82 and 86 via a cable 90 leading to the controller 12 in Fig. 1.

[0028] The two thermal coupling members 83, 87, as well as the two tubes 84, 88, are of a metal, such as stainless steel, having relatively good thermal conductivity. The coupling members 83, 87 include relatively thin web portions 83a, 87a, respectively, between the thermal sensor elements 82, 86 and the metal tubes 84, 88, so as to provide a good thermal coupling between the liquid flowing through the two metal tubes and their respective thermal sensor elements. The cover 81, fixed to the common H-shaped housing 80 in any suitable manner, presses the metal tubes 84, 88 firmly against their respective metal coupling members 83, 87.

Overall Operation

[0029] The overall operation of the thermal treatment apparatus illustrated in the drawings is as follows:

[0030] The catheter 2 is inserted into the urethra of the subject until the inflatable anchoring section 21 at the proximal end passes through the subject's bladder neck. An unheated fluid, preferably air, is introduced via inlet 27 and passageway 28 into the interior of the anchoring section 21 to inflate it. This anchors section 21 in the subject's bladder, wherepon the cylindrical heating section 22 of the catheter extends through the sub-

ject's prostate.

[0031] A heating fluid, such as water, is then pumped from the container 50 via pump 6 into the inlet 25 of passageway 24a, to fill the catheter and to inflate the cylindrical heating section 22 of the catheter. Additional water is added to the catheter (e.g., via a separate inlet in the connector connecting the catheter to the closed circuit) to completely fill the closed circuit including container 50 and the catheter 2. The water heated within container 50 is circulated by the peristaltic pump 6 through the closed circuit including the cylindrical heating section 22 of the catheter.

[0032] During the circulation of the heating liquid, the sensor assemblies 8, 10 sense the temperature of the heating liquid near the inlet and outlet ends of the catheter, respectively. These sensor assemblies, together with the thermal sensors 44 in the electrical heater 4, control the controller 12 to maintain the desired temperature. Only the inflated heating section 22 of the catheter is effective to heat tissue, because of the thermal insulation provided by the unheated air within the anchoring section 21 of the catheter, and within chambers 30 of the remaining portion of the catheter. Accordingly, the liquid applied to the inflatable heating section 22 may be heated to a relatively high temperature for application to the tissue within the prostate, with less danger of unduly heating other tissue contacted by the catheter. The inflation of the heating section 22 of the catheter also presses that section firmly against the tissue to be thermally treated thereby further enhancing the heating effects.

[0033] Drain opening 32 at the proximal end of the catheter, and passageway 33 through the catheter, provide a drain for the bladder liquids or enable the introduction of a drug into the bladder.

[0034] While the invention has been described with respect to one preferred embodiment, it will be appreciated that many other variations, modifications and applications of the invention may be made as long as they are covered by the claims.

Claims

1. Thermal treatment apparatus for thermally treating selected tissues of a subject located in or near a body cavity, comprising:

   a catheter (2) insertable into the subject's body cavity and including a proximal end formed with an inflatable anchoring section (21) for anchoring the catheter (2) in the body cavity, a distal end (23) to be located externally of the body cavity, and an inflatable heating section (22) adjacent the proximal end to be located near the tissue to be heated; the catheter (2) being formed with first and second passageways (24a, 24b) extending from the distal end (23) to the inflatable heating section (22) for circulating heated fluid through the inflatable heating section (22) but not through the inflatable anchoring section (21); and a third passageway (28) from the distal end (23) to the inflatable anchoring section (21) for inflating the inflatable anchoring section (21) with a non-heated fluid, whereby the inflatable heating section (22) and the tissue in its proximity may be heated to a desired high temperature without correspondingly heating the inflatable anchoring section (21) and the tissue in its proximity;

   a heater (4) for heating a fluid;

   a pump (6) for circulating the fluid in a closed circuit defined by the heater (4), the pump (6), the first passageway (24a), the inflatable heating section (22), and the second passageway (24b);

   a first thermal sensor assembly (8) near the inlet end of the first passageway (24a) for measuring the temperature of the heated fluid entering the first passageway (24a), and a second thermal sensor assembly (10) near the outlet end of the second passageway (24b) for measuring the temperature of the heated fluid exiting from the second passageway (24b), wherein said first and second thermal sensor assemblies (8, 10) are spatially separate and located externally of the subject during operation; and

   a controller (12) which controls the heater (4) and the pump (6) to maintain a desired temperature of the heated fluid based on the temperature sensed by the first and second thermal sensor assemblies (8, 10).

2. The apparatus according to claim 1, wherein the portion of the catheter (2) from the distal end (23) to the heating section (22) includes an outer chamber (30) enclosing the first and second passageways (24a, 24b) for thermally insulating from the heated fluid any tissue near or in contact with the portion of the catheter (2) from the distal end (23) to the heating section (22).

3. The apparatus according to claim 2, wherein the outer chamber (30) is divided into a plurality of separate compartments extending axially of the catheter (2).

4. The apparatus according to one or more of claims 1-3, wherein the catheter (2) includes a fourth passageway (33) extending centrally of the catheter (2) and communicating with an opening (32) in the proximal end of the catheter (2) to drain liquid from the body cavity to the distal end (23) or to introduce a drug into the body cavity.

5. The apparatus according to one or more of claims

1-4, wherein the heating section (22) of the catheter (2) is of cylindrical configuration.

6. The apparatus according to one or more of claims 1-5, wherein the heater (4) includes:

a heating block (40) formed with a smoothly curved cavity (41);
a container (50) defining a fluid reservoir and formed with a complementary-curved wall (51) removably receivable in the curved cavity (41);
a cover (54) attached to the container (50);
a fluid inlet tube (56) passing through the cover (54) for inletting a fluid into the container (50) to be heated by the heating block (40); and
a fluid outlet tube (58) passing through the cover (54) for outletting a fluid from the container (50) after having been heated by the heating block (40).

7. The apparatus according to claim 6, wherein the dimensions of the curved wall (51) of the container (50) are slightly smaller than those of the smoothly curved cavity (41) of the heating block (40), to provide a small gap for receiving a fluid having good thermal coupling characteristics.

8. The apparatus according to claim 6, wherein the smoothly curved cavity (41) of the heating block (40), and the complementary-curved wall (51) of the container (50), are both of semi-spherical configuration.

9. The apparatus according to claim 6, wherein the heating block (40) is made of a material having high thermal conductivity and includes at least one electrical heating element (43) encased therein.

10. The apparatus according to one or more of claims 1-9, wherein the pump (6) is a peristaltic pump and includes:

a housing (60) formed with a cylindrical cavity (61); and
a rotor (62) rotatably mounted with the cylindrical cavity (61) and carrying rollers (65) engageable with a peristaltic tube (66) insertable into the cylindrical cavity (61) for pressing the peristaltic tube (66) against a wall of the housing (60) in order to pump a liquid through the peristaltic tube (66) during the rotation of the rotor (62);
the wall of the housing (60) including a skirt (72) depending from a lid (70) removably received over the cylindrical cavity (61);
the depending skirt (72) extending less than the circumference of the lid (70) to produce an interruption in the housing wall against which the peristaltic tube (66) is pressed by the rollers (65) of the rotor (62).

11. The apparatus according to claim 10, wherein an inner surface of the depending skirt (72) is formed with a groove (77) to produce a pulsatile liquid flow.

12. The apparatus according to one or more of claims 1-11, wherein the first and second thermal sensor assemblies (8, 10) includes respective thermal sensors (82, 86) which are in thermal communication with a respective metal tube (84, 88) having a wall and being configured to allow the circulating heated fluid to travel therethrough such that, in operation, the wall of the metal tube (84, 88) heats to a temperature corresponding to the temperature of the heated fluid traveling therethrough.

13. The apparatus according to one or more of claims 1-11, wherein each of the thermal sensor assemblies (8, 10) includes:

a thermal sensor (82, 86);
a metal tube (84, 88) connectable to the respective end of the respective passageway (24a, 24b) of the catheter (2) to receive the heated fluid flowing therethrough;
a metal thermal coupling member (83, 87) formed with a recess on one face for receiving the thermal sensor (82, 86) therein, a recess on the opposite face complementary to the shape of the metal tube (84, 88) for receiving the metal tube (84, 88) therein, and a relatively thin web (83a, 87a) between the two recesses; and
a cover (81) pressing the metal tube (84, 88) to the thermal coupling member (83, 87).

14. The apparatus according to claim 1, wherein the portion of the catheter (2) from the distal end (23) to the heating section (22) includes an outer chamber (30) enclosing the first and second passageways (24a, 24b) and communicating with the third passageway (28) so as also to receive non-heated fluid for thermally insulating from the heated fluid any tissue near or in contact with the portion of the catheter (2) from the distal end (23) to the heating section (22).

Patentansprüche

1. Vorrichtung zur thermischen Behandlung für die thermische Behandlung selektierter Gewebe einer Person, das sich in einem Körperhohlraum oder nahe daran befindet, die folgendes umfasst:

einen Katheter (2), der in einen Körperhohlraum der Person einführbar ist und der ein pro-

ximales Ende einschließt, das mit einem aufblasbaren Verankerungsabschnitt (21) ausgebildet ist, um den Katheter (2) im Körperhohlraum zu verankern, ein distales Ende (23) einschließt, das außerhalb des Körperhohlraums angebracht werden soll, und angrenzend am proximalen Ende einen aufblasbaren Erwärmungsabschnitt (22) einschließt, um in der Nähe des zu erwärmenden Gewebes befindlich zu sein; wobei der Katheter (2) mit einem ersten und einem zweiten Durchgang (24a, 24b) ausgebildet ist, die sich vom distalen Ende (23) zum aufblasbaren Erwärmungsabschnitt (22) erstrecken, um das erwärmte Fluid durch den aufblasbaren Erwärmungsabschnitt (22), aber nicht durch den aufblasbaren Verankerungsabschnitt (21) zu zirkulieren; und einen dritten Durchgang (28) vom distalen Ende (23) zum aufblasbaren Verankerungsabschnitt (21), um den aufblasbaren Verankerungsabschnitt (21) mit einem nicht-erwärmten Fluid aufzublasen, wodurch der aufblasbare Erwärmungsabschnitt (22) und das Gewebe in seiner Nähe auf eine gewünschte hohe Temperatur erhitzt werden können, ohne dass entsprechend der aufblasbare Verankerungsabschnitt (21) und das Gewebe in seiner Nähe erwärmt werden;
ein Heizgerät (4) zum Erwärmen eines Fluids;
eine Pumpe (6), damit das Fluid in einem vom Heizgerät (4), von der Pumpe (6), vom ersten Durchgang (24a), vom aufblasbaren Erwärmungsabschnitt (22) und vom zweiten Durchgang (24b) bestimmten Umlaufkreis zirkuliert wird;
einen ersten Wärmesensoraufbau (8) in der Nähe des Einlassendes des ersten Durchgangs (24a) zum Messen der Temperatur des in den ersten Durchgang (24a) eintretenden erwärmten Fluids, und einen zweiten Wärmesensoraufbau (10) in der Nähe des Auslassendes des zweiten Durchgangs (24b) zum Messen der Temperatur des aus dem zweiten Durchgang (24b) austretenden Fluids, worin der erste und der zweite Wärmesensoraufbau (8, 10) räumlich getrennt sind und sich während des Betriebs außerhalb der Person befinden; und
ein Steuergerät (12), das das Heizgerät (4) und die Pumpe (6) steuert, damit eine gewünschte Temperatur des erwärmten Fluids auf der Grundlage der vom ersten und vom zweiten Wärmesensoraufbau (8, 10) abgetasteten Temperatur aufrechterhalten bleibt.

2. Die Vorrichtung nach Anspruch 1, worin der Abschnitt des Katheters (2) vom distalen Ende (23) zum Erwärmungsabschnitt (22) eine Außenkammer (30) einschließt, die den ersten und den zweiten Durchgang (24a, 24b) umschließt, um thermisch jedes in der Nähe des Abschnitts des Katheters (2) oder damit in Kontakt befindliche Gewebe vom distalen Ende (23) bis zum Erwärmungsabschnitt (22) vom erwärmten Fluid zu isolieren.

3. Die Vorrichtung nach Anspruch 2, worin die Außenkammer (30) in eine Vielzahl von getrennten Fächern aufgeteilt wird, die sich axial vom Katheter (2) erstrecken.

4. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-3, worin der Katheter (2) einen vierten Durchgang (33) einschließt, der sich in der Mitte des Katheters (2) erstreckt und der mit einer Öffnung (32) im proximalen Ende des Katheters (2) in Verbindung steht, um Flüssigkeit aus dem Körperhohlraum zum distalen Ende (23) zu entleeren oder um ein Arzneimittel in den Körperhohlraum einzuführen.

5. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-4, worin der Erwärmungsabschnitt (22) des Katheters (2) einen zylindrischen Aufbau hat.

6. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-5, worin das Heizgerät (4) folgendes einschließt:

einen Heizblock (40), der mit einem leicht gekrümmten Hohlraum (41) ausgebildet ist;
einen Behälter (50), der einen Fluidbehälter bestimmt und der mit einer komplementär gekrümmten Wand (51) ausgebildet ist, die im gekrümmten Hohlraum (41) entnehmbar aufgenommen werden kann;
einen am Behälter (50) angebrachten Deckel (54);
eine Fluideinlassröhre (56), die durch den Deckel (54) passiert, um ein Fluid in den Behälter (50) einzulassen, das vom Heizblock (40) erwärmt werden soll; und
eine Fluidauslassröhre (58), die durch den Deckel (54) passiert, um ein Fluid aus dem Behälter (50) herauszulassen, nachdem es vom Heizblock (40) erwärmt wurde.

7. Die Vorrichtung nach Anspruch 6, worin die Abmessungen der gekrümmten Wand (51) des Behälters (50) etwas kleiner sind als jene des leicht gekrümmten Hohlraums (41) des Heizblocks (40), um einen kleinen Zwischenraum bereitzustellen, damit ein Fluid empfangen wird, das gute Wärmekopplungseigenschaften hat.

8. Die Vorrichtung nach Anspruch 6, worin der leicht gekrümmte Hohlraum (41) des Heizblocks (40) und die komplementär gekrümmte Wand (51) des Behälters (50) beide halbsphärische Anordnung sind.

9. Die Vorrichtung nach Anspruch 6, worin der Heizblock (40) aus einem Material gemacht ist, das eine hohe thermale Leitfähigkeit aufweist, und mindestens ein darin umschlossenes Heizelement (43) einschließt.

10. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-9, worin die Pumpe (6) eine peristaltische Pumpe ist und folgendes einschließt:

ein mit einem zylindrischen Hohlraum (61) ausgebildetes Gehäuse (60); und
einen Rotor (62) der mit dem zylindrischen Hohlraum (61) drehbar gelagert ist und der Rollen (65) trägt, die mit einem peristaltischen Schlauch (66) im Eingriff stehen können, der in den zylindrischen Hohlraum (61) gesteckt werden kann, um den peristaltische Schlauch (66) gegen eine Wand des Gehäuses (60) zu drükken, damit eine Flüssigkeit während der Drehung des Rotors (62) durch den peristaltischen Schlauch (66) gepumpt wird;

wobei die Wand des Gehäuses (60) eine von einem Deckel (70) herabhängende Schürze (72) einschließt, die abnehmbar über dem zylindrischen Hohlraum (61) aufgenommen wird;
wobei sich die herabhängende Schürze (72) weniger als der Umfang des Deckels (70) erstreckt, um eine Unterbrechung in der Gehäusewand zu erzeugen, gegen die die peristaltische Pumpe (66) von den Rollen (65) des Rotors (62) gedrückt wird.

11. Die Vorrichtung nach Anspruch 10, worin eine Innenfläche der herabhängenden Schürze (72) mit einer Vertiefung (77) ausgebildet ist, um einen pulsierenden Flüssigkeitsstrom zu erzeugen.

12. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-11, worin der erste und der zweite Wärmesensoraufbau (8, 10) jeweilige Wärmesensoren (82, 86) einschließen, die mit einer jeweiligen Metallröhre (84, 88) in thermischer Verbindung stehen, die über eine Wand verfügten und aufgebaut sind, um zu erlauben, dass das erwärmte zirkulierende Fluid derart dadurch strömt, dass sich während des Betriebs die Wand der Metallröhre (84, 88) auf eine Temperatur erwärmt, die der Temperatur des dadurchgehenden erwärmten Fluids entspricht.

13. Die Vorrichtung nach einem oder mehreren der Ansprüche 1-11, worin jeder der Wärmesensoraufbauten (8, 10) folgendes einschließt:

einen Wärmesensor (82, 86);
eine Metallröhre (84, 88), die mit dem jeweiligen Ende des jeweiligen Durchgangs (24a, 24b) des Katheters (2) verbunden werden kann, um das dadurchfließenende erwärmte Fluid zu empfangen;
ein Metall-Wärmekopplungsglied (83, 87), das mit einem Einschnitt an einer Oberfläche ausgebildet ist, um den Wärmesensor (82, 86) darin aufzunehmen, einem Einschnitt an der gegenüberliegenden Oberfläche ausgebildet ist, die mit der Form der Metallröhre (84, 88) komplementär ist, um die Metallröhre (84, 88) darin aufzunehmen, und mit einem relativ dünnen Gewebe (83a, 87a) zwischen den zwei Einschnitten ausgebildet ist; und
einen Deckel (81), der die Metallröhre (84, 88) an das Wärmekopplungsglied (83, 87) drückt.

14. Die Vorrichtung nach Anspruch 1, worin der Abschnitt des Katheters (2) vom distalen Ende (23) bis zum Erwärmungsabschnitt (22) eine Außenkammer (30) einschließt, die den ersten und den zweiten Durchgang (24a, 24b) umschließt und die mit dem dritten Durchgang (28) in Verbindung steht, um auch das nichterwärmte Fluid zu empfangen, damit jedes in der Nähe des Abschnitts des Katheters (2) oder damit in Kontakt befindliche Gewebe vom distalen Ende (23) bis zum Erwärmungsabschnitt (22) thermisch isoliert wird.

Revendications

1. Appareil de traitement thermique pour traiter thermiquement des tissus sélectionnés d'un sujet situé dans ou à proximité d'une cavité corporelle, comprenant :

un cathéter (2) insérable dans la cavité corporelle du sujet et comportant une extrémité proximale munie d'une section d'ancrage gonflable (21) pour ancrer le cathéter (2) dans la cavité corporelle, une extrémité distale (23) à placer à l'extérieur de la cavité corporelle, et une section chauffante gonflable (22) adjacente à l'extrémité proximale à placer près du tissu à chauffer ; le cathéter (2) étant muni d'un premier et d'un deuxième passages (24a, 24b) s'étendant de l'extrémité distale (23) à la section chauffante gonflable (22) pour faire circuler un fluide chauffé dans la section chauffante gonflable (22) mais pas dans la section d'ancrage gonflable (21); et un troisième passage (28) de l'extrémité distale (23) à la section d'ancrage gonflable (21) pour gonfler la section d'ancrage gonflable (21) avec un fluide non chauffé, grâce à quoi la section chauffante gonflable (22) et le tissu présent dans son voisinage peuvent être chauffés jusqu'à une température élevée souhaitée sans faire chauffer de manière correspondante la section d'ancrage

gonflable (21) et le tissu présent dans son voisinage ;
un dispositif de chauffage (4) pour chauffer un fluide ;
une pompe (6) pour faire circuler le fluide dans un circuit fermé défini par le dispositif de chauffage (4), la pompe (6), le premier passage (24a), la section chauffante gonflable (22), et le deuxième passage (24b) ;
un premier ensemble formant capteur thermique (8) près de l'extrémité d'entrée du premier passage (24a) pour mesurer la température du fluide chauffé entrant dans le premier passage (24a), et un deuxième ensemble formant capteur thermique (10) près de l'extrémité de sortie du deuxième passage (24b) pour mesurer la température du fluide chauffé sortant du deuxième passage (24b), lesdits premier et deuxième ensembles formant capteur thermique (8, 10) étant séparés dans l'espace et placés à l'extérieur du sujet pendant l'opération ; et
un contrôleur (12) qui commande le dispositif de chauffage (4) et la pompe (6) pour maintenir une température souhaitée du fluide chauffé en fonction de la température mesurée par les premier et deuxième ensembles formant capteur thermique (8, 10).

2. Appareil selon la revendication 1, dans lequel la partie du cathéter (2) allant de l'extrémité distale (23) à la section chauffante (22) comporte une chambre extérieure (30) renfermant les premier et deuxième passages (24a, 24b) pour isoler thermiquement du fluide chauffé tout tissu se trouvant à proximité ou au contact de la partie du cathéter (2) allant de l'extrémité distale (23) à la section chauffante (22).

3. Appareil selon la revendication 2, dans lequel la chambre extérieure (30) est divisée en une pluralité de compartiments distincts qui s'étendent dans la direction axiale du cathéter (2).

4. Appareil selon l'une ou plusieurs des revendications 1 à 3, dans lequel le cathéter (2) comporte un quatrième passage (33) qui s'étend au centre du cathéter (2) et communique avec une ouverture (32) située dans l'extrémité proximale du cathéter (2) pour drainer du liquide de la cavité corporelle à l'extrémité distale (23) ou pour introduire un médicament dans la cavité corporelle.

5. Appareil selon l'une ou plusieurs des revendications 1 à 4, dans lequel la section chauffante (22) du cathéter (2) est de configuration cylindrique.

6. Appareil selon l'une ou plusieurs des revendications 1 à 5, dans lequel le dispositif de chauffage (4) comporte :

un bloc chauffant (40) muni d'une cavité à courbe douce (41) ;
un récipient (50) définissant un réservoir à fluide et muni d'une paroi à courbure complémentaire (51) pouvant être reçu de manière amovible dans la cavité incurvée (41) ;
une enveloppe (54) fixée au récipient (50) ;
un tube d'entrée (56) de fluide passant à travers l'enveloppe (54) pour permettre l'entrée d'un fluide dans le récipient (50) devant être chauffé par le bloc chauffant (40) ; et
un tube de sortie (58) de fluide passant à travers l'enveloppe (54) pour permettre la sortie d'un fluide du récipient (50) après qu'il ait été chauffé par le bloc chauffant (40).

7. Appareil selon la revendication 6, dans lequel les dimensions de la paroi incurvée (51) du récipient (50) sont légèrement inférieures à celles de la cavité à courbe douce (41) du bloc chauffant (40), pour constituer un petit interstice destiné à recevoir un fluide ayant de bonnes caractéristiques de couplage thermique.

8. Appareil selon la revendication 6, dans lequel la cavité à courbe douce (41) du bloc chauffant (40) et la paroi à courbure complémentaire (51) du récipient (50) sont toutes deux de configuration semi-sphérique.

9. Appareil selon la revendication 6, dans lequel le bloc chauffant (40) est fait d'un matériau ayant une conductivité thermique élevée et comporte au moins un élément chauffant électrique (43) enfermé dedans.

10. Appareil selon l'une ou plusieurs des revendications 1 à 9, dans lequel la pompe (6) est une pompe péristaltique et comporte :

un boîtier (60) muni d'une cavité cylindrique (61) ; et
un rotor (62) monté à rotation avec la cavité cylindrique (61) et portant des rouleaux (65) pouvant coopérer avec un tube péristaltique (66) insérable dans la cavité cylindrique (61) pour presser le tube péristaltique (66) contre une paroi du boîtier (60) afin de pomper un liquide par le tube péristaltique (66) pendant la rotation du rotor (62) ;
la paroi du boîtier (60) comportant une jupe (72) qui pend depuis un couvercle (70) reçu de façon amovible sur la cavité cylindrique (61) ;
la jupe pendante (72) s'étendant moins que la circonférence du couvercle (70) pour produire une interruption dans la paroi du boîtier contre

laquelle le tube péristaltique (66) est pressé par les rouleaux (65) du rotor (62).

11. Appareil selon la revendication 10, dans lequel une surface intérieure de la jupe pendante (72) est munie d'une rainure (77) afin de produire un flux de liquide pulsatile.

12. Appareil selon l'une ou plusieurs des revendications 1 à 11, dans lequel les premier et deuxième ensembles formant capteur thermique (8, 10) comportent des capteurs thermiques respectifs (82, 86) qui sont en communication thermique avec un tube métallique respectif (84, 88) ayant une paroi et configuré pour permettre au fluide chauffé en circulation de passer à l'intérieur de telle manière que, en fonctionnement, la paroi du tube métallique (84, 88) chauffe jusqu'à une température correspondant à la température du fluide chauffé qui passe à l'intérieur.

13. Appareil selon l'une ou plusieurs des revendications 1 à 11, dans lequel chacun des premier et deuxième ensembles formant capteur thermique (8, 10) comporte :

un capteur thermique (82, 86) ;
un tube métallique (84, 88) pouvant être connecté à l'extrémité respective du passage respectif (24a, 24b) du cathéter (2) pour recevoir le fluide chauffé qui s'y écoule ;
un élément de couplage thermique en métal (83, 87) muni d'un évidement sur une face pour y recevoir le capteur thermique (82, 86), un évidement sur la face opposée complémentaire de la forme du tube métallique (84, 88) pour y recevoir le tube métallique (84, 88), et une bande relativement mince (83a, 87a) entre les deux évidements ; et
une enveloppe (81) pressant le tube métallique (84, 88) sur l'élément de couplage thermique (83, 87).

14. Appareil selon la revendication 1, dans lequel la partie du cathéter (2) allant de l'extrémité distale (23) à la section chauffante (22) comporte une chambre extérieure (30) renfermant les premier et deuxième passages (24a, 24b) et communiquant avec le troisième passage (28) de façon à également recevoir du fluide non chauffé pour isoler thermiquement du fluide chauffé tout tissu se trouvant à proximité ou au contact de la partie du cathéter (2) allant de l'extrémité distale (23) à la section chauffante (22).

SYSTEM BLOCK DIAGRAM

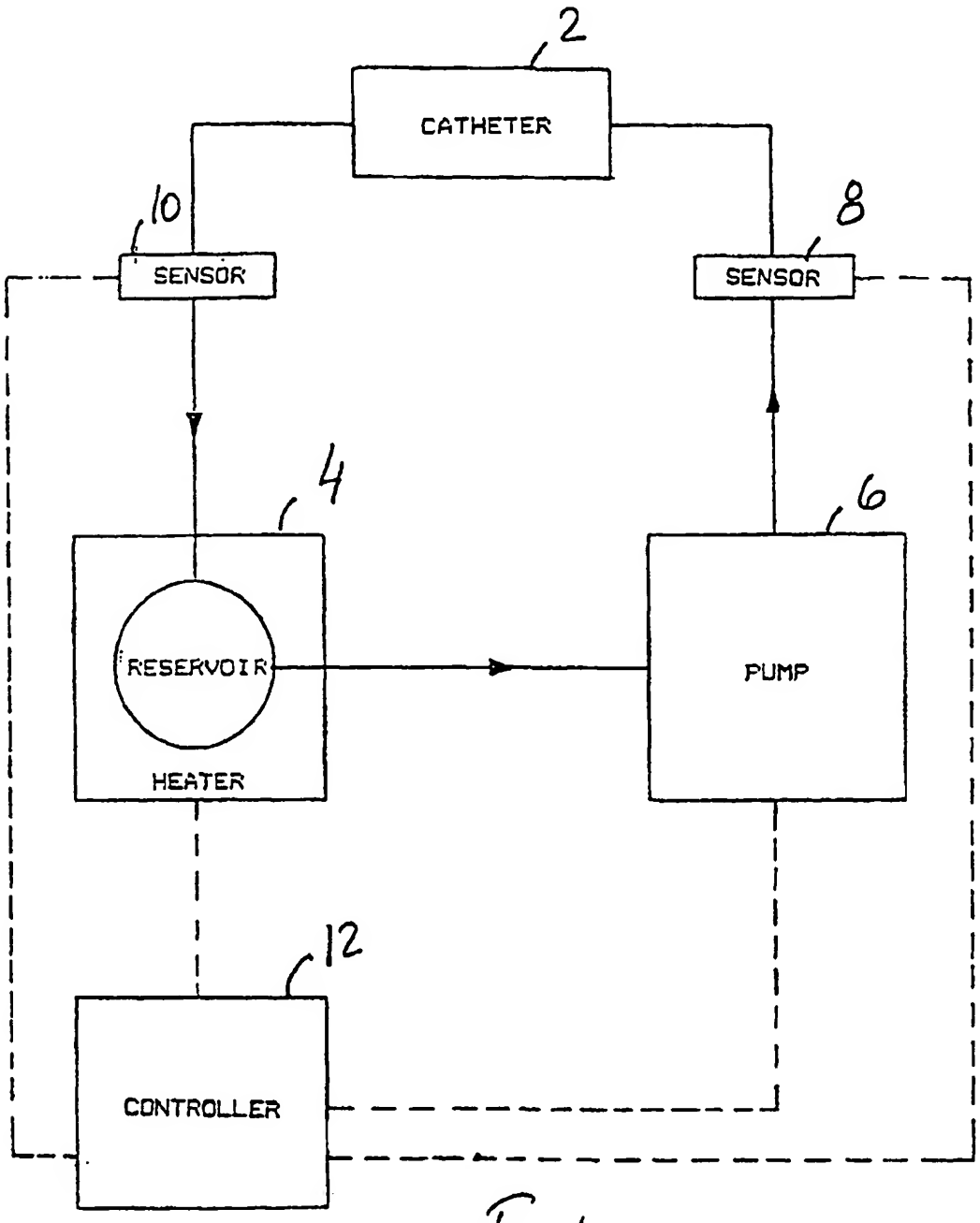
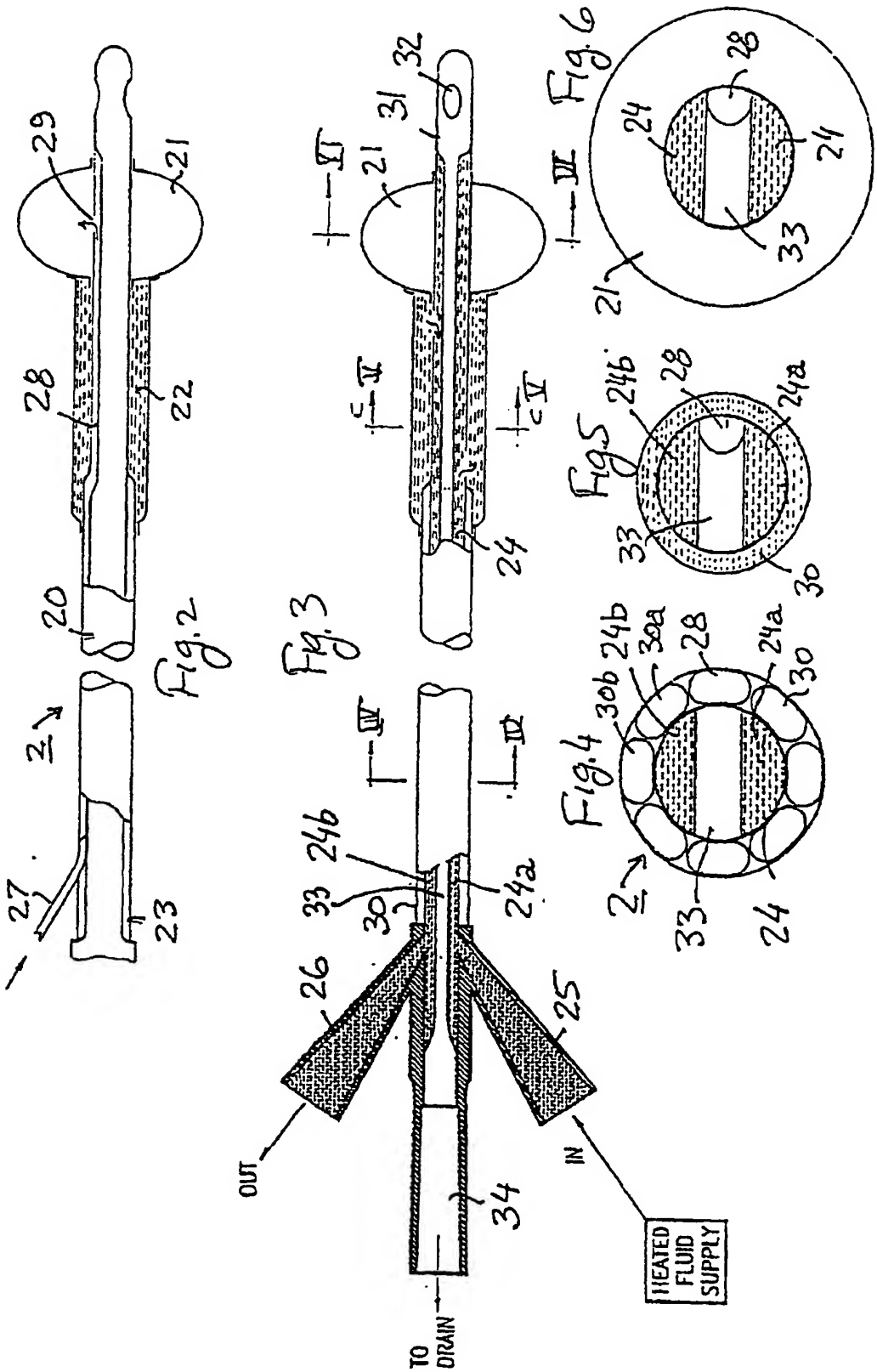


Fig.1


29
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23
Fig.2
31
32
21
V
V
24
Fig.3
VI
VI
Fig.6
28
24
24
33
21
Fig.5
24b
28
24a
33
30
IV
IV
33
24b
30
24a
26
25
OUT
IN
34
TO DRAIN
HEATED FLUID SUPPLY
Fig.4
30b
24b
30a
28
24a
30
2
33
24

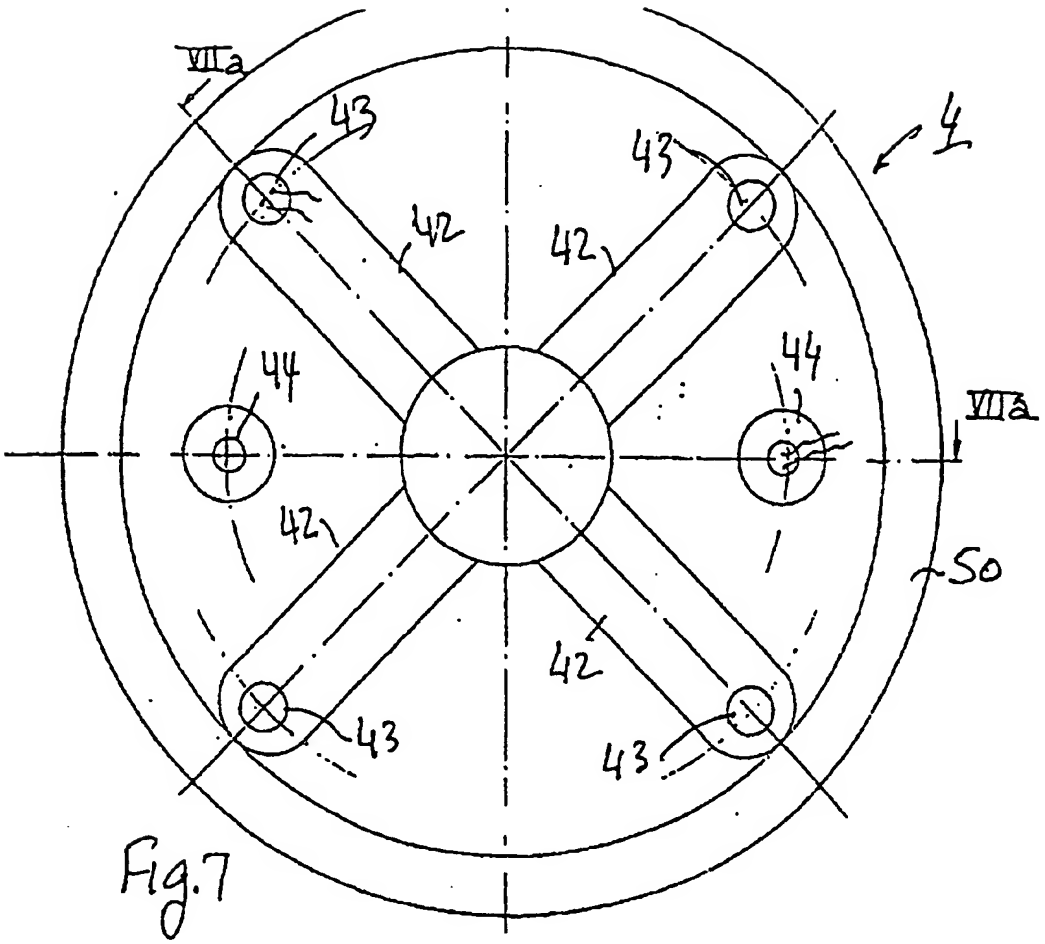


Fig.7

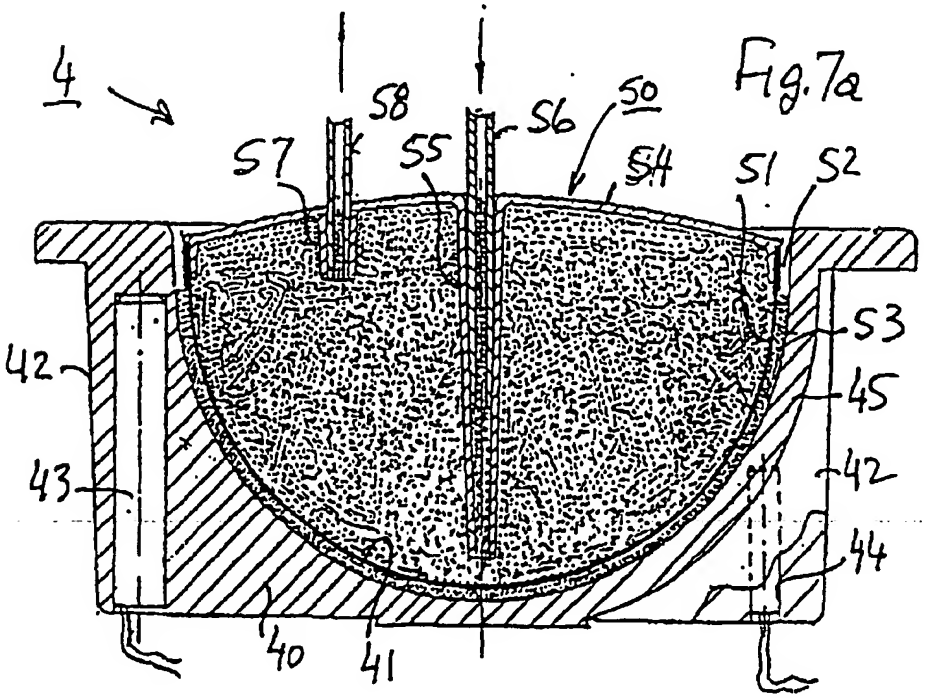


Fig.7a

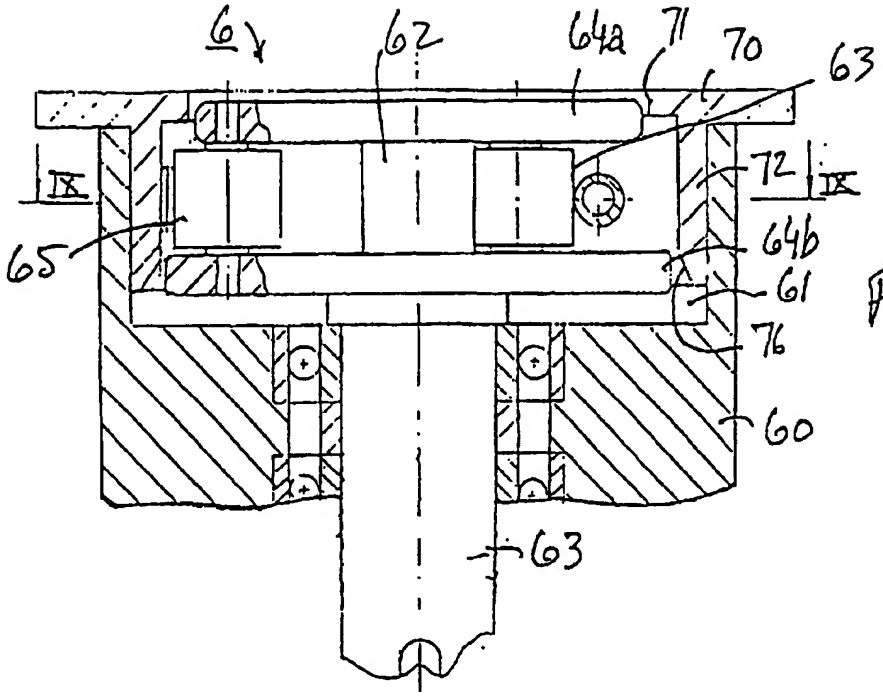


Fig 8

Fig. 9

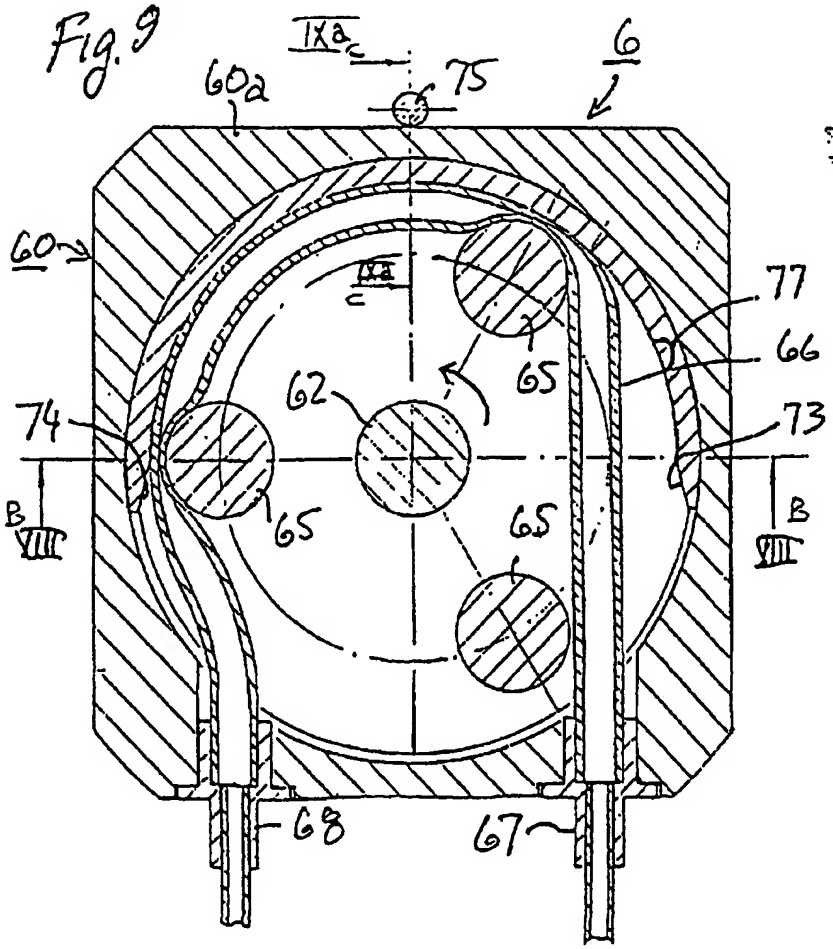


Fig. 9a

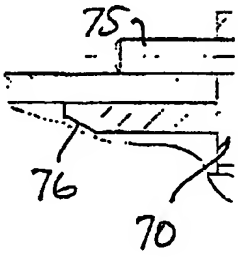
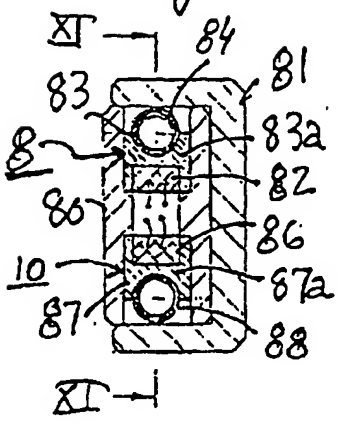


Fig.10


XI
84
81
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83a
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87a
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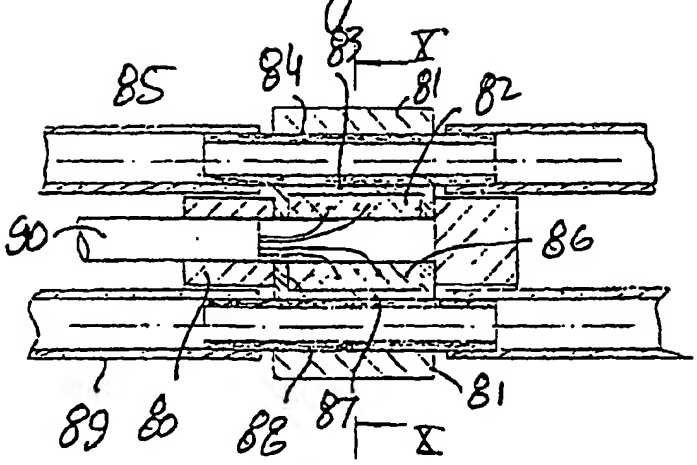
XI

Fig.11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